

## CLAIMS

1. A piezoelectric ceramic composition comprising:  
a phase comprising, as a main component, lead zirconate titanate having a perovskite structure; and  
an Al-containing phase.
2. The piezoelectric ceramic composition according to claim 1, wherein:  
said main component comprises Mn and Nb.
3. The piezoelectric ceramic composition according to claim 1, wherein:  
said main component is represented by a composition formula of  $Pb_\alpha[(Mn_{1/3}Nb_{2/3})_xTi_yZr_z]O_3$  (wherein  $0.97 \leq \alpha \leq 1.01$ ,  $0.04 \leq x \leq 0.16$ ,  $0.48 \leq y \leq 0.58$ ,  $0.32 \leq z \leq 0.41$ ).
4. The piezoelectric ceramic composition according to claim 1, wherein:  
said Al-containing phase comprises  $Al_2O_3$ .
5. The piezoelectric ceramic composition according to claim 1, wherein:  
said piezoelectric ceramic composition is composed of a sintered body comprising grains and grain boundaries exist between said grains; and  
 $Al_2O_3$  is contained in said grains and is precipitated in said grain boundaries.

6. The piezoelectric ceramic composition according to claim 1, wherein:

    said piezoelectric ceramic composition comprises  $\text{Al}_2\text{O}_3$  in an amount of 0.15 to 15.0 wt%.

7. The piezoelectric ceramic composition according to claim 1, wherein:

$|\Delta F_0|$  which is the absolute value of the rate of change in oscillation frequency  $F_0$  thereof, before and after application of a thermal shock, is 0.10% or less; and

    the three-point flexural strength  $\sigma_{b3}$  thereof is 160 N/mm<sup>2</sup> or more.

8. A piezoelectric ceramic composition comprising:

    a main component represented by the formula of  $\text{Pb}_\alpha[(\text{Mn}_{1/3}\text{Nb}_{2/3})_x\text{Ti}_y\text{Zr}_z]\text{O}_3$ , wherein  $\alpha$ ,  $x$ ,  $y$  and  $z$  fall within the ranges of  $0.97 \leq \alpha \leq 1.01$ ,  $0.04 \leq x \leq 0.16$ ,  $0.48 \leq y \leq 0.58$  and  $0.32 \leq z \leq 0.41$ , respectively; and

    as an additive, at least one element selected from the group consisting of Al, Ga, In, Ta and Sc in an amount of 0.01 to 15.0 wt% in terms of an oxide of each element.

9. The piezoelectric ceramic composition according to claim 8, wherein:

    said piezoelectric ceramic composition has  $\alpha$ ,  $x$ ,  $y$  and  $z$  of said main component falling within the range of  $0.98 \leq \alpha < 1.00$ ,  $0.06 \leq x \leq 0.14$ ,  $0.49 \leq y \leq 0.57$  and  $0.33 \leq z \leq 0.40$ ,

respectively.

10. The piezoelectric ceramic composition according to claim 8, wherein:

said piezoelectric ceramic composition has  $\alpha$ ,  $x$ ,  $y$  and  $z$  of said main component falling within the range of  $0.99 \leq \alpha < 1.00$ ,  $0.07 \leq x \leq 0.11$ ,  $0.50 \leq y \leq 0.55$  and  $0.34 \leq z \leq 0.39$ , respectively.

11. The piezoelectric ceramic composition according to claim 8, wherein:

said piezoelectric ceramic composition comprises Al as said additive in an amount of 0.05 to 5.0 wt% in terms of  $\text{Al}_2\text{O}_3$ .

12. The piezoelectric ceramic composition according to claim 8, wherein:

said piezoelectric ceramic composition comprises Al as said additive in an amount of 0.15 to 1.5 wt% in terms of  $\text{Al}_2\text{O}_3$ .

13. The piezoelectric ceramic composition according to claim 8, wherein:

said piezoelectric ceramic composition comprises Si in an amount of 0.005 to 0.15 wt% in terms of  $\text{SiO}_2$ .

14. The piezoelectric ceramic composition according to claim 8, wherein:

the electric property  $Q_{\max}$  ( $Q_{\max} = \tan\theta$ :  $\theta$  is a phase angle) thereof is 30 or more;

$|\Delta k_{15}|$  which is the absolute value of the rate of change in electromechanical coupling factor  $k_{15}$  thereof, before and after application of a thermal shock, is 4% or less;

$|\Delta F_0 (-40^\circ\text{C})|$  which is the absolute value of the rate of change in oscillation frequency  $F_0$  thereof at  $-40^\circ\text{C}$ , with reference to  $20^\circ\text{C}$ , is 0.4% or less; and

$|\Delta F_0 (85^\circ\text{C})|$  which is the absolute value of the rate of change in oscillation frequency  $F_0$  thereof at  $85^\circ\text{C}$ , with reference to  $20^\circ\text{C}$ , is 0.4% or less.

15. A piezoelectric ceramic composition comprising a sintered body comprising; as a main component, a perovskite compound having mainly Pb, Zr, Ti, Mn and Nb; and as an additive, at least one element selected from the group consisting of Al, Ga, In, Ta and Sc, wherein:

the electric property  $Q_{\max}$  ( $Q_{\max} = \tan\theta$ :  $\theta$  is a phase angle) thereof is 100 or more;

$|\Delta k_{15}|$  which is the absolute value of the rate of change in electromechanical coupling factor  $k_{15}$  thereof, before and after application of a thermal shock, is 2% or less;

$|\Delta F_0 (-40^\circ\text{C})|$  which is the absolute value of the rate of change in oscillation frequency  $F_0$  at  $-40^\circ\text{C}$  thereof, with reference to  $20^\circ\text{C}$ , is 0.2% or less; and

$|\Delta F_0 (85^\circ\text{C})|$  which is the absolute value of the rate of change in oscillation frequency  $F_0$  at  $85^\circ\text{C}$  thereof, with reference to  $20^\circ\text{C}$ , is 0.2% or less.

16. The piezoelectric ceramic composition according to claim 15, wherein:

said sintered body comprises  $\text{Al}_2\text{O}_3$ .

17. The piezoelectric ceramic composition according to claim 15, wherein:

said sintered body comprises a main component represented by the formula of  $\text{Pb}_\alpha[(\text{Mn}_{1/3}\text{Nb}_{2/3})_x\text{Ti}_y\text{Zr}_z]\text{O}_3$ , wherein  $\alpha$ ,  $x$ ,  $y$  and  $z$  fall within the range of  $0.99 \leq \alpha < 1.00$ ,  $0.07 \leq x \leq 0.14$ ,  $0.50 \leq y \leq 0.55$  and  $0.34 \leq z \leq 0.39$ , respectively.